DEADLY MAINTENANCE

1985

PLANT AND MACHINERY
A Study of Fatal Accidents at Work

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PREFACE

This short report about the dangers to which people are exposed while engaged in the maintenance* of plant and machinery forms part of a wider study carried out by the Accident Prevention Advisory Unit (APAU) of the Health and Safety Executive (HSE).† It is based on information contained in reports of fatal accidents which occurred in 1980, 1981 and 1982. The reports were prepared by Agricultural Inspectors, Factory Inspectors and Mines and Quarries Inspectors.

The objective of this report is to make available to a wider audience the lessons learned first-hand by some people at the cost of the life of a colleague or friend. It is hoped in doing so that the dangers are fully appreciated, the causes of accidents are understood, and the use of safe systems of work is promoted.

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*The definition of 'Maintenance' used for the purposes of the study was "the repair, restoration or cleaning of process machinery, plant, vehicles, buildings, structures and roads."

†*'Deadly Maintenance',* a report prepared by the Accident Prevention Advisory Unit of the Health and Safety Executive and obtainable from HMSO.

'Deadly Maintenance - Roofs', a report prepared by the Accident Prevention Advisory Unit of the Health and Safety Executive and obtainable from HMSO.

FOREWORD

Most people will recognise the essential nature of maintenance work, but perhaps few will fully appreciate its potential to kill or seriously injure workpeople.

The title 'Deadly Maintenance' may appear emotive, but it is merely a true reflection of the facts; more than 100 people killed a year.

This publication is an attempt to draw attention to what actually happens, and to offer some ideas on prevention.

There can be few people or industries who will not at some time be affected by maintenance activities. I commend this report to them in the hope that it will foster not only a clear understanding, but also a new commitment to tackle this appalling record.

John Rimington

J D Rimington Director General HSE

ANALYSIS OF PLANT AND MACHINERY MAINTENANCE

Introduction

1 People are in most cases protected from danger by the design of the plant, by physical safeguards or by safety devices. But maintenance, whether emergency repairs, routine servicing or cleaning, usually involves access into hazardous areas not normally approached. The work is more than likely to be done under pressure to hand back the plant for normal production. This is a combination of circumstances which can be fatal.

2 One hundred and six people died maintaining plant and machinery within the period covered by this report. This is 33% of all maintenance fatal accidents. *Well over three quarters could have been prevented if reasonably practicable precautions had been taken.*

Maintenance Activities

3 Breakdowns or scheduled repairs were in progress when 66% of the fatal accidents occurred. A further 25% happened during cleaning operations and the remaining 9% during examination, lubrication and painting.

Type of Machinery & Plant

4 Table A gives details of the type of machinery or plant involved. The high number of conveyor and elevator accidents can perhaps be explained by the wide extent of their use. Nevertheless, the dangers and appropriate precautions are, or should be, well known. The lesson is there for all to learn.

TABLE A: SHOWING THE MAIN TYPES OF PLANT AND MACHINERY INVOLVED IN MAINTENANCE FATAL ACCIDENTS

	TYPE OF MACHINERY OR PLANT	NUMBER OF FATAL ACCIDENTS	TOTALS
MACHINERY	Conveyors and Elevators	23	
	Cranes (a)	9	
	Agricultural Machines (b)	9	
	Other Factory Process Machines	5	
	Coal or Mineral Cutting Machines (c)	5	
	Other Mine or Quarry Machines	5	
	Lifts (d)	3	
	Concrete Hoppers and Process Mixers	3	
	Steel Process Machines	2	
	Carding Machines	2	
TOTAL - ALL MACHINERY			66
PLANT	Storage Tanks	7	
	Furnaces and Associated Plant	6	
	Boilers, Heating and Ventilation Plant	5	
	Chemical, Gas, Oil Process Plant	5	
	Dust or Fume Extraction Plant	5	
	Degreasing Tanks	4	
TOTAL - ALL PLANT			32
PLANT AND MACHINERY NOT ELSEWHERE CLASSIFIED		8	8
TOTAL PLANT AND MACHINERY MAINTENANCE FATAL ACCIDENTS			106

(a) Includes two ore unloaders

(b) Includes combine harvesters, forage trailers and a peat milling machine

(c) Includes drilling and tunnelling machines

(d) Includes a mine shaft skip

People

5 It was perhaps to be expected that maintenance fitters would account for the largest number of deaths. This was in fact the case (37%). What is perhaps more surprising is the proportion which occurred to production operatives (33%) and labourers (7%). This cannot be entirely explained by cleaning operations.

6 Service engineers were not immune, being involved in 6%. Thirteen per cent were managers, supervisors or proprietors, a figure which tempts the conclusion that at times the blind were indeed leading the blind

Type of Accident

7 The 106 cases were analysed to give an indication of the type of accident and the results are given in Table B.

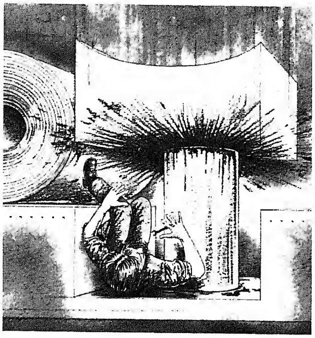
(a) Crushed by Machinery

8 Fifty accidents involved moving machinery. The majority were due to contact with power-driven parts or because the victim was trapped between the machine and a fixed structure. Cleaning, adjustment, lubrication or testing of the machine were often carried out near to moving parts and at times with limited room to manoeuvre. This is the clearest indication that guards or safeguards continue to be removed without taking steps to achieve mechanical or electrical isolation.

> 'A fitter became entangled with a tail drum and projecting shaft on a troughed conveyor. He was attempting to 'track' the belt at the tail drum. The side guard had

A view of the end drum and tension rollers of a wide flat belt conveyor. Man's body drawn up to the shoulder in the inrunning nip. A bent cleaning tool evident, ie rake.

Man's clothing caught on the picks of a coal face cutting machine. Man drawn against fixed parts of the machine.



Hydraulic powered steel coil elevator, carriage in raised position. Man lying underneath removing the oil seal loosened. Gravity descent of carriage.

> been removed to allow access to the adjusting mechanism.'

9 Further lives were lost due to gravity falls of parts of machines. It appears that the possibility or consequences of such events were not recognised. The systems of work, where they existed, certainly did not include measures to counter this hazard.

> 'A fitter was killed when the elevator carriage and stripper plate of a coil stripper in a steel works descended trapping him. The elevator was in the raised position to give access to the hydraulic ram. When gland sealing ring was removed the hydraulic fluid leaked out and the unchocked elevator carriage dropped.'

10 Poor design of machinery or safety devices was also a relevant factor.

> 'A factory operator was trapped when the door of a concrete mixer closed while he had his head inside the machine during cleaning operations. An electrical fault caused the door to shut. It had been installed by the suppliers so that during a power failure the door would automatically close preventing any loss of concrete mix.'

(b) Falls

11 Twenty people died as a result of falling from heights, mainly from working platforms or from the structure of the plant or machine itself. In over half the accidents, there was a failure to provide either a safe means of access or a safe working place despite the fact that maintenance had previously taken place at that location.

> 'A refrigeration maintenance engineer fell from an unprotected platform while checking a compressor. The platform was in the factory roof space and was regularly used during the week.'

12 Unclear arrangements about the erection and use of factory-owned equipment, such as work cradles, by contractors' employees featured in a number of incidents.

> 'Two welders of a crane testing company fell from a cradle. They were working in a cradle suspended from an overhead travelling crane. The wrong lugs had been used to sling the cradle and these gave way while the welders were in the cradle.'

(c) Burns

13 Ten people suffered fatal burns. There were a variety of agents including ignited flammable vapours, molten metal, exploding dust, steam and hot water. Many of these accidents happened in tanks or other confined spaces. The common thread running through a number of these incidents was the absence of a clear safe method of work, inadequate supervision and inadequate head office support for on-site crews.

TABLE B: SHOWING THE TYPES OF ACCIDENTS ASSOCIATED WITH THE MAINTENANCE OF PLANT AND MACHINERY

ACCIDENT TYPE	TOTAL NUMBER OF FATAL ACCIDENTS	
Machinery - Crushed by gravity fall machine parts or residual energy motion	11	
- Entanglement powered moving parts machines	17	
- Crushed between fixed & powered moving parts machines	12	
- Crushed between moving machines and structure	10	50
Falls from - Work Platforms	7	
- Ladders	2	
- Plant/Machinery	8	
Falls through fragile Roof/Ceilings	2	
Falls from Plant due to rupture of vessel	2	21
Burns - Hot Liquids/Gases/Dusts/Metal		10
Gassing		9
Electrocution		6
Asphyxiation		5
Struck by Falling Materials		4
Struck by Falling Plant due to Lifting Tackle failure		1
TOTAL		106

'A foreman painter working inside a partially closed water tank using an airless paint spraying system died in an explosion. He was wearing a helmet for protection against fumes. He knocked an electric lamp off the edge of the tank. The explosion of vapour caused fatal body burns. The lamp was not a type approved for use in flammable atmospheres.'

(d) Gassing or Asphyxiation

14 Solvent fumes, leaking process gases, smoke from fires and granular solids were responsible for the gassing or asphyxiation of 14 people. The four incidents where people were overcome by solvent vapours at degreasing tanks deserve special mention. Work was carried out with little or no precautions. People failed to understand that dangerous levels of solvent readily build up, even in open-topped tanks. The remedies are, or should be, well known.*

> 'A director of a newly established company was asphyxiateed by trichloroethylene fumes. He was working on his own and went into a standard degreasing tank to check the bottom. There were a few gallons of trichloroethylene in the tank and he collapsed and died before he was found.'

15 Welding operations by contractors started fires inside large items of plant killing factory employees. This was a result of failures to properly plan and co-ordinate the work of different groups of men.

> 'A plant operator was asphyxiated when cotton/phenolic resin dust ignited. During a shutdown period an oven was being cleaned and maintained. The deceased was inside an after burner chamber. At the same time a welder was welding ducting connected directly to the chamber and ignited the resin dust.'

(e) Electrocution

16 Four of the six cases could have been prevented if the electrical supply had been isolated. Defective wiring in the plugs of two steam or pressurised hot water cleaning machines resulted in the chassis becoming electrically charged in a wet environment. Service engineers, working alone on site, formed the majority of those killed.

> 'A service engineer was electrocuted while repairing an ozone generator installed in the plant room of a swimming pool. He restored power to the generator which resulted in a fuse blowing. Knowing that the HT side of the generator was dead it appeared that he reached in to the cabinet to remove the HT lead. His left hand touched the bare terminals of the heater bands energised at mains potential.'

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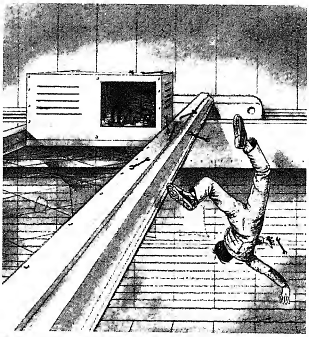
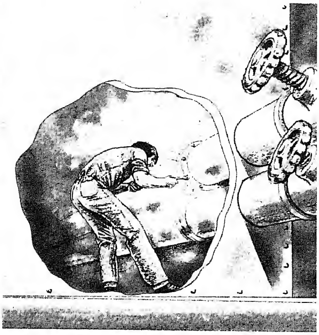
*Guidance Note EH5 *Trichloroethylene: health and safety precautions,* HMSO, ISBN 0 11 883030 9

Man sitting on the narrow steel beam forming part of an overhead crane crab. Repairing electrical control box of the crane. Falls off.

Large round oil storage tank being cleaned by spraying paraffin from a rotating head. Electrical lights via top hatch. Explosion, 3 men killed, flying metalwork and bricks.



Man inside an empty storage tank, unbolting a joint of steam heating coil pipes. Live steam escapes. Man burned.



Cleaning the bottom of a degreasing tank. Man collapsed inside the tank. Overcome by residual vapours.

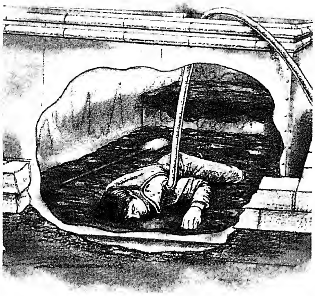


TABLE C: SHOWING THE MAJOR CAUSE OF ACCIDENTS
DURING THE MAINTENANCE OF PLANT AND MACHINERY

NB: Major Cause - The single most important factor in the chain of events leading to each fatal accident

MAJOR CAUSE OF ACCIDENT	NUMBER OF FATALITIES
Absence or failure in system of work	35
Absent or defective equipment, guards, or working platforms	23
Failure of management organisation or supervision	11
Inadequate or lack of training, instruction or information	8
Human Error	10
Unauthorised activity	5
Defective design of plant or machinery (Section 6 HSW Act 1974)	5
Unknown or unforeseeable incident	9
TOTAL	106

Repair of a pressurised water cleaning machine.
Electrical powered by 13 amp plug. Wet area on floor.
Man electrocuted.

Cause of Accidents

17 Any accident, fatal or otherwise, rarely occurs because of one single factor. However, one cause may appear to be more significant than the others. The accidents were analysed to try to identify the major cause. For the purpose of this study 'Major Cause' was defined as "the single most important factor in the chain of events leading to the fatal accident". The results of this analysis are shown at Table C.

18 It is quite clear from this analysis that in 51% of the cases, management failed to implement and supervise safe working procedures or to instruct and train their employees.

19 A further 22% were caused simply by failures to achieve basic safety standards, mainly in guarding of machinery and fencing of work platforms.

Precautions

20 Analysis of the accident reports reveals that 78% of the accidents could have been prevented if reasonably practicable precautions had been implemented. It is tempting to explain this away by attributing it to human error, but it is necessary to look beyond this aspect. The results of this study show quite clearly that the answer lies in management applying their minds to the problems involved, in identifying the hazards, implementing and monitoring systems of work. *In other words, maintenance, like other aspects of business, needs proper management.*

21 Figure 1 illustrates a suggested framework within which maintenance activities can be planned and controlled. A breakdown in one or more of the following key elements featured in these accidents.

(a) Design
Good initial design can do much to minimise maintenance problems. The need to approach dangerous parts may be reduced by the use of proximity guards or translucent materials, and the provision of external lubrication

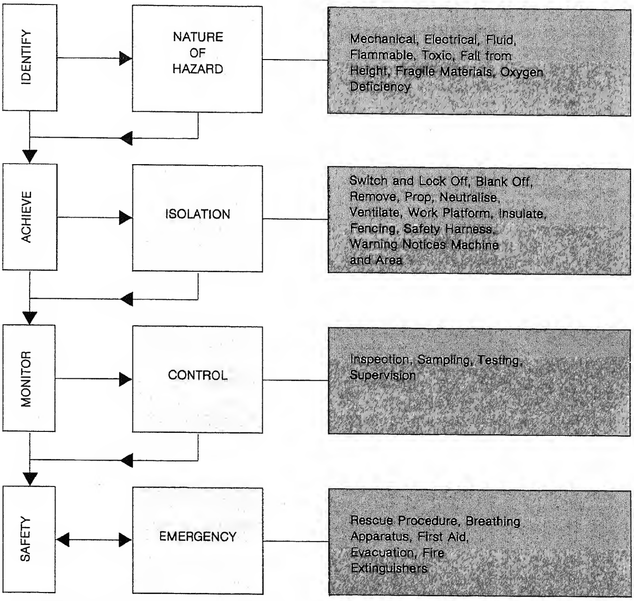
points or adjustment devices. Means of controlled manual cranking, true inching or slow crawl can be a considerable aid to safe maintenance practices where guards have to be removed. Suitable means of isolating the hazards are important, such as lockable electrical isolators, props to prevent gravity fall. Safe access and working platforms for maintenance purposes should not be ignored. This may mean permanent walkways, or, for infrequent access, fixtures for attaching temporary structures. Tanks should be provided with adequately proportioned manholes to aid the entry and escape of people, possibly wearing breathing apparatus.

(b) Management
Maintenance needs to be properly managed. High risk activities require supervision by suitably experienced staff if failure and death are to be avoided. There will undoubtedly be occasions when local expertise is limited and specialist outside assistance will need to be obtained. The tendency for maintenance departments to attempt to cope must be avoided. Their boundaries of performance must be recognised, and strictly enforced.

(c) Information
Clear information about the correct safe procedures should be available to the people actually doing the maintenance work. Accurate plans and circuit diagrams with the valves and controls of the plant or machinery correctly identified need to be provided. The hazards associated with the normal process materials should not be overlooked.

(d) Training
Maintenance often involves work in situations where the normal production safeguards no longer apply. Training to a high standard is invariably required, with particular attention to safe working practices in hazardous environments.

FIGURE 1: PLANNING FOR MAINTENANCE


IDENTIFY
NATURE OF HAZARD
Mechanical, Electrical, Fluid, Flammable, Toxic, Fall from Height, Fragile Materials, Oxygen Deficiency
ACHIEVE
ISOLATION
Switch and Lock Off, Blank Off, Remove, Prop, Neutralise, Ventilate, Work Platform, Insulate, Fencing, Safety Harness, Warning Notices Machine and Area
MONITOR
CONTROL
Inspection, Sampling, Testing, Supervision
SAFETY
EMERGENCY
Rescue Procedure, Breathing Apparatus, First Aid, Evacuation, Fire Extinguishers

(e) Planning
The existence, nature and extent of hazards can be more accurately assessed in a calm atmosphere, rather than in the heat of the moment of a faltering maintenance operation. Clear and appropriately detailed procedures should be drawn up for all foreseeable maintenance operations. The extent of those plans will obviously vary with the type of hazard. It may be a simple manufacture's manual, a basic plant isolation procedure or a full written permit to work procedure. A system should define the extent of the maintenance activity and not only the precautions required to safeguard the people involved but also any others working in the premises. Contractors' activities should not be ignored. Whatever system is adopted it is essential that the hazard remains isolated for the full duration of the work.

(f) Equipment
A wide variety of special purpose testing or safety equipment may be necessary for maintenance operations. A tendency to use home-made devices has sometimes been noted. Such equipment can be deadly.

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Safety equipment should be compatible with type of work or it may not be used. It must be appropriate for the hazards involved or the dangers will be increased. If it is to function as designed it must be kept in good working order. Hence the importance of regular inspection and servicing. It is equally important that personnel are trained in the correct procedures for its use.

The correct equipment should be readily available for use so that the temptation to make do is avoided.

(g) Implementation

The benefits of the planning can only be gained if the procedures are fully implemented. If that is the case the plant or machinery should be promptly returned to production without loss of life.

The laid down systems must be applied in every detail and checks made to ensure that safe conditions have been achieved before work commences.

If the planned procedures are found *not* to isolate the hazards then work should stop immediately, until appropriate expertise can be applied to solve the problem.

(h) Monitoring

People must be protected throughout the duration of the work. Conditions should be monitored periodically, or in some cases continuously. Inspection by experienced management with appropriate authority should be adequate in most situations, but more exhausive checks may be necessary, eg atmospheric testing.

(i) Rescue

The meticulous application and monitoring of a planned safe working procedure should make any comments about emergency rescue systems superfluous or at least rarely applicable.

But mistakes do happen. The rapid removal of unconscious or badly injured people from still dangerous situations may be needed.

If a multiple fatality is to be avoided, it is important that the range of possible failures has been considered and plans laid to stabilise the situation, then to achieve a rescue without risking further lives. It is essential that training in rescue procedures is given if people are to act calmly when required.

Conclusions

22 The maintenance of plant or machinery involves people working in dangerous situations not encountered during normal production operations. These unconventional activities occur across the whole range of plant and machinery, and result in employees of all occupational types from labourers to directors being killed. ***It is quite clear that the main responsibility for reducing the death toll lies with management.*** If people are not to die in what, in a lot of cases, are tragic and horrific circumstances, management must plan and control its plant and machinery maintenance work.

23 Proper safe systems of work do not just happen, they must be developed. If they are not, a further hundred or so lives may be lost in the next three years!

CASE STUDY: CONVEYORS AND ELEVATORS

Twenty-three fatal accidents resulted from the maintenance of conveyors and elevators, the largest single type of machinery. Life was lost in 17 cases due to crushing or entanglement in machinery; the others died from falls or were buried under the materials being conveyed.

Seven of these accidents involved repairs, 12 cleaning of the conveyor systems and a further three adjustment to conveyor belt tracking.

The major causes of these accidents were: the lack of safe systems of work; inadequate physical safeguards and failures in the management organisation. This case study is typical.

A bucket elevator, part of a series of process materials handling conveyors and elevators, jammed and stopped. Initial investigations by the shift superintendent indicated that the overload device for the elevator drive motor had tripped. An attempt to re-set the device, and re-start the elevator failed. The elevator was then electrically isolated by removal of a circuit board in the substation. Those concerned were under pressure to re-start the plant to maintain production, and hence the normal written job card was not issued. Maintenance fitters removed the lower sections of the elevator guards to establish the cause of the stoppage. When some material had been removed from the base of the elevator the elevator power supply was restored by an electrician and the substation locked. Operation of the elevator revealed that a number of buckets were damaged. Repairs were commenced without isolating the elevator. The work was not completed before the end of the shift and two other maintenance personnel continued the task unaware that the system was not isolated. One of these fitters also finished his shift before the task was completed. Another colleague took on the job blissfully ignorant of the situation. When the repairs were completed an electrician was called to reconnect the supposedly isolated power supply. The newly arrived plant operator pulled out the plant stop button. Shortly afterwards one of the fitters was found crushed between the bottom of the drum of the elevator and the floor. The guards were not in place.

LOCATION	MINERAL PROCESSING FACTORY
EQUIPMENT	BUCKET ELEVATOR
OPERATION	BREAKDOWN
PEOPLE	FITTERS AND ELECTRICIANS
ACCIDENT	CRUSHING
RESULT	DEATH

An electrician was then sent to isolate the plant. He removed the substation circuit board marked with the number by which the elevator was known. The elevator itself was not clearly identified. The removal of the circuit board did not in fact isolate the plant in question. Thus, while rescue operations were in progress, the elevator was still not isolated and further personnel, including the emergency services were placed at risk.

During normal production use, the conveyors and elevators were adequately guarded and did not present a hazard to production personnel. The company had, however, recognised the danger potential in powered motion of the elevator during maintenance operations and had introduced a system requiring a fitter to use his personal padlock to maintain power isolation. It was not consistently used, partly because of the need to locate an electrician from somewhere within the extensive site each time isolation or re-start of machinery was required. In addition, there was no system for maintaining plant isolation from shift to shift, the plant itself was not clearly identified and the substation circuit board was inadequately marked.

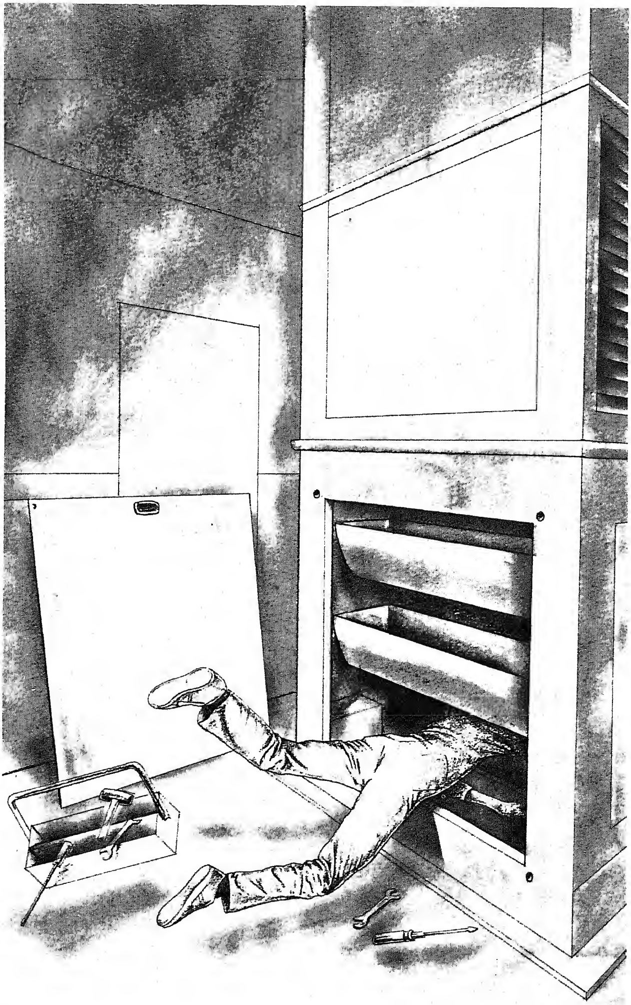
Discussions between the company and the inspector led to the following measures being taken:

- A survey of all elevators was carried out to establish the necessary modifications to plant and procedures.
- An interlocked mesh guard was installed at the elevator ground level access point, thus preventing powered motion of the elevator whilst there was access to the dangerous parts of the machine.
- The plant and its associated electrical control equipment in the substation were clearly identified.
- A cranking device was installed to inch round the elevator buckets.
- A method was provided to allow installation of adequately proportioned isolating pins (chocks) during maintenance work to prevent non-powered motion of the elevator.
- A written safe system of work was introduced which included monitoring arrangements to ensure that adequate safety standards were maintained through shift changes, and improved communications procedures so that appropriate personnel were aware of the existing conditions.

The important lessons which should be learnt from this tragic accident are that if a system of work is indeed to be a safe one, it must not only take into account the actual operating conditions but also the precautions adopted must themselves be reasonably practicable for the appropriate personnel to carry out.

CONVEYORS AND ELEVATORS

TYPE	DEATHS
Flat or Trough Belt Conveyors	17
Bucket Elevators	2
Other Vertical Elevators	2
Overhead Carrier Conveyor	1
Horizontal Moving Tray Conveyor	1
TOTAL	23



CASE STUDY: OVERHEAD TRAVELLING CRANES

Seven maintenance personnel were killed whilst working on overhead travelling cranes. Falls from the crane bridge were the most common type of accident, closely followed by the crushing of fitters between the moving crane and fixed parts of the building or crane.

All these accidents involved the repair or refurbishing of cranes. They were also used as a mobile working platform for the maintenance of high level parts of buildings, often without adequate precautions.

The main causes of these accidents were a failure to provide or maintain a safe system of work; inadequate training, instruction or information; unsafe working platforms and poor management performance. This case study is a typical accident.

A maintenance fitter and a young apprentice were sent to carry out routine maintenance and repairs to three cranes in one bay of the works. The crane track was approximately 91m (100 yds) long and 12m (13 yds) above ground level. An access staging was provided midway along the bay. The bridge walkway of the cranes was reached by a fixed ladder located at the rear of the driver's cab.

When work on the second crane was completed, the tools were placed on the crane bridge walkway, and the apprentice was asked to drive the crane to where the third crane was parked. As the crane moved slowly along the track the fitter, who was standing on the bridge walkway, was crushed between a roof truss and a fixed part of the crane. The clearance between the roof trusses and this crane was minimal, unlike that in the case of the other two cranes on the same track.

LOCATION	IRON FOUNDRY
EQUIPMENT	OVERHEAD TRAVELLING CRANE
OPERATION	ROUTINE REPAIR & MAINTENANCE
PEOPLE	MAINTENANCE FITTER & APPRENTICE
ACCIDENT	CRUSHING
RESULT	DEATH

The method for working on cranes had developed by custom and practice. Maintenance personnel were sometimes expected to lock out the crane or track electrical power isolator. Fitters were also required to ride on overhead crane walkways for maintenance purposes. It was the practice to crouch down and to shout instructions to the driver. Shouted signals were readily misinterpreted, even in low background noise conditions. Employees involved in maintenance work were authorised crane drivers, and apprentices were allowed to drive under the supervision of a colleague. None had received any training. Clearly defined safe working practices had not been laid down, but limited arrangements merely evolved. After the accident, the following measures were promptly implemented:

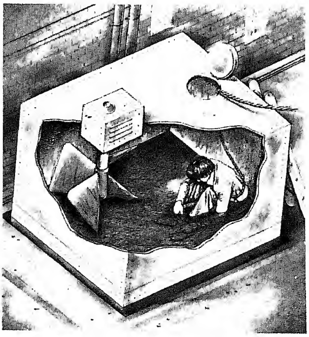
- A survey of all cranes was carried out to identify those which had limited roof clearance. Prominent notices were posted on the relevant cranes and the particular plant description cards suitably marked.
- A programme for training maintenance personnel in crane driving was introduced. Authorisation certificates were later issued.
- Apprentices under 18 years of age were prohibited from driving cranes.
- A number of plant modifications were initiated to provide a safe means of access and transfer between cranes for maintenance purposes.
- A platform was fitted on the side of the crane track in the middle of the bay to enable maintenance work to be carried out on the cranes.

Quite clearly, maintenance work on or near to overhead travelling cranes constitutes a potentially high risk activity which, if not properly planned and controlled, can lead to serious injury or more likely loss of life. A written permit to work system is normally the most appropriate procedure, not only to ensure that the law is fully observed, but more importantly to achieve safe working conditions. The particular vulnerability to accidents of contractors or other outsiders coming into a strange environment is a feature that every permit to work system should take fully into account.

People should not ride on bridge walkways whilst cranes are in motion.

OVERHEAD TRAVELLING CRANES

TYPE OF ACTIVITY	DEATHS
Repair of breakdown in crane mechanisms	3
Modification or refurbishing of cranes	3
Routine maintenance of cranes	1
TOTAL	7



CASE STUDY: CONFINED SPACES

Twenty-seven people died from gassing, asphyxiation or drowning. Twelve cases involved high solvent vapour concentrations in confined spaces, or escaping process gases and five lives were lost due to oxygen deficiency in enclosed spaces. Other people were overcome by smoke from fires started within plant during welding operations or were buried under process materials such as coal or sand.

The main causes of these accidents were: the absence of an adequate safe system of work; failures in the management organisation; unsuitable or defective equipment; and a failure to provide appropriate instruction, information and training.

Death by gassing, due to exposure to high solvent vapour levels in confined or semi-confined spaces, occurred in six of these incidents. The accident outlined below illustrates the dangers and includes in one event many of the factors which can lead to loss of life.

A tank of approximately 3.4m^3 (120 cu ft) capacity was used for holding and mixing resins used in production of expanded foam materials. The tank had an access manhole 355mm (14 in) in diameter. A few months after the tank was installed, operating problems, associated with incomplete mixing, were encountered. Since the tank was full with a mixture of Trichlorofluoromethane and resin, it was decided to wait until the liquid level had dropped sufficiently to expose the mixing blades before acting. Three weeks later the liquid level had dropped to approximately 229mm (9 in) from the bottom of the tank. A departmental manager, with the knowledge of one of the company directors, arranged for a maintenance fitter to replace the blades.

A rope was tied around the fitter's waist. He entered the tank through the manhole, but came out immediately complaining about the fumes. He was given a cartridge respirator, but found it difficult to breathe when wearing it. The filter cover had been left in place. A plastic hose was connected to the compressed air supply and the end was poked inside the respirator. The fitter re-entered the tank and again had difficulty in breathing. The respirator was taken off. The manager tried to rescue him by pulling on the rope, but help was needed before this could be achieved. The fitter never regained consciousness.

LOCATION	ELECTRICAL PRODUCTS FACTORY
EQUIPMENT	PROCESS STORAGE TANK
OPERATION	MODIFICATION OF PLANT
PEOPLE	MAINTENANCE FITTER & MANAGER
ACCIDENT	GASSING
RESULT	DEATH

The concentration of Trichlorofluoromethane vapours inside the tank was later found to be up to 77 times greater than the Threshold Limit Value*, and the atmosphere did not have enough oxygen to support normal breathing. The available manufacturer's literature warned that high concentrations of vapours could induce unconsciousness and may prove fatal.

Entry into confined spaces is a high risk operation. Specific requirements were included in the 1961 Factories Act (Section 30) and more detailed advice published†. Before any work starts, at the very least, the following points should be carefully considered;

- The Tank Atmosphere - is it safe to enter?
  in particular, are any toxic or flammable vapours present, or is the oxygen level deficient. The most desirable option would always by to arrange for atmospheric sampling to be carried out.
- Empty the tank
  make the atmosphere inside the tank safe by removing the contents to a suitable temporary store facility. Use mechanical ventilation to remove residual vapours. Finally test the atmosphere to ensure that it is safe for people to enter.
- Dangerous atmospheres
  where emptying the tank is not practicable it may be acceptable for a properly trained person wearing suitable breathing apparatus and a safety harness with lifeline to enter the tank. A second person, capable of pulling the person out of the tank, should keep watch. Cartridge respirators are not generally capable of providing adequate protecion at the vapour concentrations likely to be found within confined spaces. They are of no help in oxygen deficient atmospheres.*† A certificate of entry into the tank should be issued by a responsible person.
- Manholes
  the manhole should be large enough not only to allow entry of a person possibly wearing breathing apparatus, but also the rescue of an unconscious person.
- Rescue
  a rescue and first aid procedure should be clearly laid down just in case of unforeseen complications. Unfortunately, in such circumstances the unplanned rescue attempt all too often results in multiple deaths.
- Training
  Use of the equipment and operation of the procedures outlined above rely to a large extent on the provision of adequate training for the personnel involved. The equipment itself of course needs to be maintained in correct working order, because when it is required it must function as designed if life is to be preserved.
- Extra hazards
  the risks associated with rotating mixing machinery or liquid inflow need to be properly isolated before work commences.

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*HSE Guidance Note EH40 *Occupational Exposure Limits 1984* available from HMSO price £2.50
ISBN 011 883560 2

†HSE Guidance Note GS5 *Entry into Confined Spaces*, available from HMSO, price 30p
ISBN 011 883067 8

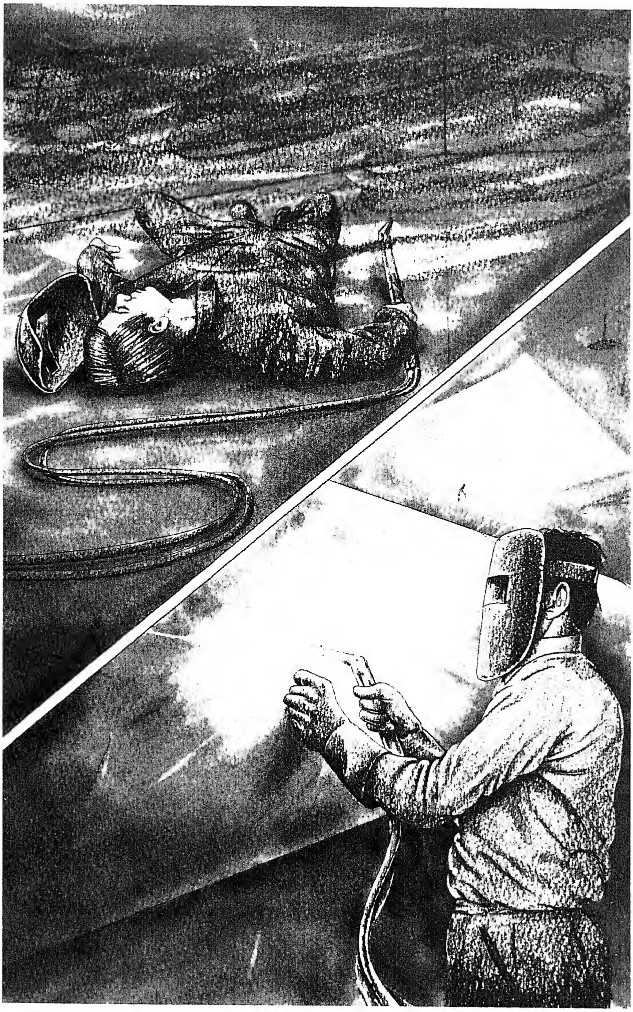
*†BS 4275:1974 - *Recommendations for the selection, use & maintenance of respiratory protective equipment*

BS 1397:1979 & BS 3367:1980 refer to specifications for safety harnesses & lifelines.

The main lesson to be learned from this type of incident is that a planned safe system of work is essential and its meticulous implementation vital. A clearly defined written permit to work procedure is usually appropriate to confined space activities.

GASSING & ASPHYXIATION ACCIDENTS

MAINTENANCE ACTIVITY AND ACCIDENT TYPE	NUMBER OF DEATHS
Solvent Vapours whilst cleaning degreasing tanks	4
Solvent Vapours in tanks during repair or cleaning operations	2
Leaking process gases during plant repairs	3
Process gases from sewers or sewage treatment plant during cleaning operations	3
Oxygen deficiency in confined spaces under repair	5
Fire smoke during repairs within confined plant	2
Drowning in rivers, sea or pool	4
Asphyxiation due to engulfment in sand or coal	3
Trapped by neck in narrow aperture	1
TOTAL	27



Man working inside a furnace burner chamber. Welding elsewhere in the furnace starts an oil/grease fire. Man overcome by smoke.

1 A crane mechanic fell 6m (20 ft) from the bridge of an overhead travelling crane which he was repairing. There was a gap of 1 metre, (3ft 4in) between the RSJs forming the bridge. It is probable that he fell from the open edge of one of them.

2 A maintenance supervisor who was carrying equipment fell from a vertical ladder below the level of the steel hoops.

3 The lower guards of a bucket elevator were removed to find out why it had stalled. Replacement of a number of damaged buckets started, and was continued by maintenance fitters on the next shift. Everyone thought that the machine had been isolated in the substation, but this was not the case. When the repairs had been completed an operator pulled out the plant stop button. The guards had not been replaced. A fitter was found crushed between the bottom drum of the elevator and the floor.

4 A maintenance fitter was trapped by his arm in the unguarded tensioning rollers of an overhead conveyor belt. He died of cardiac arrest.

5 A fitter was repairing a level indicator float in a steam condensate recovery vessel. There was a kink in its flexible drain pipe leaving the vessel partially full. The fitter opened the vessel and was scalded by 227 litres (50 gallons) of boiling water.

6 A part-time worker in a scrap yard was killed when a lorry body was blown over by the wind. It had been propped on its side 10° to the vertical.

7 A rigger helping to replace and refit pipework on a boiler climbed over a handrail on a permanent gantry on to ducting to gain access through an opening. He slipped and fell 10m (32ft 10in). A safe access was available a short distance away.

8 A foreman painter was painting the inside of a partially enclosed water tank using an airless spray system. He was wearing a blasting helmet as protection against fumes. He stood up and knocked an electrical lamp off the edge of the tank. The explosion of vapour caused him severe body burns. The lamp was not approved for use in flammable atmospheres.

9 A man entered a boiler house following a leakage of blast furnace gas. He was wearing breathing apparatus. He was found unconscious. The breathing apparatus was turned off.

10 A mechanical fitter fell 3m (10ft) from a ladder while trying to carry a chain pulley block weighing 25.4 kg (56lbs) from its fixing points.

11 A man was trapped between the conveyor head discharge chute and the belt of a troughed conveyor in a steel works. It was thought that he climbed onto the conveyor and it was subsequently started up. The isolation procedure had not been followed.

12 An oiler was killed while inside the chamber of a sand mill in a foundry. It was started up, and run under power. A captive key interlock system on the machine door was defective and not maintained.

13 The deceased was spraying a refractory lining inside a cupola. He was wearing an airstream helmet. The charging hole above him had been covered with galvanised sheet steel braced with angle iron. Approximately 50 kgms (110 lbs) of iron oxide scale in large lumps fell from the top of the cupola, burst through the protective sheets hitting the deceased. No fall of such magnitude has occurred within the last 20 years.

14 A self employed service engineer was electrocuted when checking a fault on a steam cleaner he had recently repaired. The plug on the supply cable was incorrectly wired with the earth wire connected to the live phase pin.

15 A large tank used for storing fuel oil was being cleaned by a team of operators spraying paraffin which had a flash point of 65-70°C (149-158°F). Two weatherproof tungsten-halogen lamps were suspended through the hatches in the tank roof. A fire followed by an explosion killed three operators. The source of ignition was thought to be the lamps.

16 A fitter had repaired the support bracket of a roller of an inclined belt conveyor, and was checking the belt tracking. He was drawn head first into the unguarded inrunning nip between the belt and roller.

17 Two pipe fitters died removing safety relief valves from vessels of a refinery's H_2S absorption and regeneration plant. There was a gas leak from a gasket. For some unknown reason one man removed his compressed air mask. His colleague dislodged his own mask in a rescue attempt. The other possibility was that there was an interruption in the air supply such that both men removed their masks to breathe.

18 A man was overcome while removing sludge from a degreasing tank which contained trichloroethylene. He was wearing a mask and airline. No formal safe system of work had been implemented by management.

19 Two heat treatment operatives in a light engineering factory were found dead on the floor of a small canteen adjacent to a trichloroethylene distillation plant at 6 am. The control setting meant that all the trichloroethylene had spilled on the floor beneath the plant into a drain. Some had flowed into the canteen and a build up of fumes killed both operatives.

20 A greaser was trapped between a guard rail and an uncoiler mandrel on a steel strip pickling line. It appeared that the deceased had been attempting to retrieve a spanner by reaching through the guard rails.

21 A craftsman working at an ore terminal was hit by a scaffold pole which fell out of a sling. Sub-contract

crane engineers were hoisting the load to the place of work.

22 A maintenance engineer was trapped between the crab side plate of an overhead travelling crane and a roof girder. He had completed a temporary repair and instructed the transport manager to carry out a trial lifting operation while he was on the walkway adjacent to the crane tracks.

23 Two men were burnt while cleaning the inside of a blast furnace dust catcher. The contents were thought to be solid, which they were normally. The work was being done from the outside using the manholes. A sudden release of hot fine black dust enveloped the gang of 10 men.

24 A fitter was killed when the elevator carriage and stripper plate of a coil stripper in a steel works descended trapping him. The elevator was in the raised position and when the hydraulic ram gland sealing ring was removed the hydraulic fluid leaked out and the unchocked elevator carriage dropped.

25 A chargehand fitter was hit when the hinged top of a large rubber mould fell from lifting tackle which was holding it open. A tee bar connecting the hoist hook to the hinged top came off the hook.

26 The 10 year old son of a mill owner was lifted by the moving drive belt of a carding machine and came into contact with a concrete pillar. He was able to approach the main drive pulley and belt because the side guards were inadequate.

27 A brewery fitter was killed while maintaining a cask hoist (vertical elevator). He was carried up inside the hoistway after accidentally activating a photo electric device. It was not practice to isolate the hoist after final use for the day.

28 A fitter's mate fell 5m (16ft 6in) through a glass roof light in a factory making floor coverings while replacing an extraction duct in the roof.

29 A steelworks' welder was asphyxiated while working inside one of the recuperator stacks of a slab reheating furnace when it was filled with smoke. The source of ignition was probably greasy deposits in a fan casing. Two sub-contractors' employees had been carrying out burning work close by and had finished about 15 minutes before the smoke was first noticed.

30 A trainee operator was killed when his left arm was taken through a 4mm (0.16in) gap between a moving swift and strong steel undergrid of a carding machine. He was working in a deep pit underneath the machine cleaning the traverses of the automatic fettling equipment.

31 A plant operator was asphyxiated when cotton/phenolic resin dust ignited. During a shutdown period an oven was being cleaned and maintained. The deceased was inside an after burner chamber. At the same time a welder was welding ducting connected directly to the chamber and ignited the resin dust.

32 Two welders of a crane testing company fell from a cradle. They were working in a cradle suspended from an overhead travelling crane. The wrong lugs had been used to sling the cradle and these lugs gave way while the welders were in the cradle.

33 A hospital maintenance fitter fell 2.4m (8ft) from the top of a boiler. He was stripping fittings of the boiler shell in preparation for the boiler's 10 year test. No working platform was provided.

34 A crane driver was thrown out of a crane when a steel chimney hit the cab. The crane was lifting a steel chimney which was part of an extraction unit. The chain slings, which were provided with the crane, snapped and the chimney was deflected from a building onto the cab.

35 A factory fitter fell 5.2m (17ft) through an asbestos cement sheet roof. He was walking along the gutter carrying a tin of sealing compound.

36 The deceased fell into a cable duct 0.61m (2ft) deep when a covering plate collapsed under him. He was removing an electric gear box motor which rolled onto his leg. He was taken to hospital with a compound fracture of the leg but died later from a blood clot.

37 A millwright slid head first down a section of under guarding on a conveyor and struck his head on the floor. He was carrying out routine work on a conveyor. He was trying to free a carrier trolley when it was suddenly dislodged causing him to tumble down the under guarding.

38 A chargehand was electrocuted when he removed the cover of a bag sealing machine exposing live electrical equipment. He was carrying out an unauthorised mechanical repair and did not follow the laid down procedures which had been used successfully for a number of years.

39 A lift engineer maintaining a factory passenger lift was trapped in the pit below the lift car when someone in the factory pressed the call button on one of the landings. He had bypassed the electrical circuits allowing the lift to run with the doors open.

40 A maintenance fitter was working on an induction furnace when molten metal from an adjacent furnace erupted and burnt him. There had been a build up of carbon monoxide gas beneath the crust which was not considered to be foreseeable.

41 The deceased was trapped between the conveyor belt and gravity take up pulley at a coal handling plant. A brick had become jammed causing the conveyor drive to trip out on overload. The fitter dislodged the brick and the gravity take up pulley dropped. At the same time the tension in the conveyor belt was released, trapping him.

42 A maintenance fitter was crushed between a roof truss and an overhead

travelling crane. He was travelling on the bridge walkway. The crane, being driven by his 17 year old apprentice, was being used to taxi to another crane.

43 An electrician was electrocuted while repairing a cloth welding machine in a clothing factory. In order to test the effectiveness of the repairs he used a short cut by reaching over the machine and tripping a microswitch. A disconnected high voltage lead was resting on his foot.

44 A factory operator was trapped when the door of a concrete mixing machine closed while he had his head inside the machine during cleaning operations. An electrical fault had caused the door to shut. It had been installed by the suppliers so that in the event of power failure the door would automatically close preventing the loss of the concrete mix.

45 A deaf and dumb operator was crushed at a biscuit cooling machine during cleaning operations. The cooler had been isolated but not locked off. Guards had been removed. Another employee started the machine, unaware that the deceased was inside the machine.

46 A fitter was asphyxiated inside a tank while replacing a set of mixing blades. The fitter went through a 355mm (14in) opening with a rope round his waist, had difficulty in breathing and retreated. He then donned a cartridge respirator and inserted an air line between his cheek and the respirator. The cover for the respirator filter was left on. He went in again and found difficulty in breathing and was told by the works manager to take off the respirator. He could not get out of the tank.

47 An operator cleaning concrete from a hopper was crushed when the lifting hooks supporting the hopper came adrift. The hooks of the slings were insecurely jammed into the corner sections outside the hopper.

48 A chargehand fitter was burnt by hot gases produced by a heavy slop of molten metal. He was supervising an unrelated maintenance task and consequently was not wearing any protective clothing or head gear.

49 A refrigeration maintenance engineer fell from an unprotected platform while checking a compressor fixed on it. The platform was situated in the factory roof space and was regularly used during the week.

50 A service engineer was elecrocuted attempting to repair a computer room air conditioning unit. There was an open circuit between the incoming live and neutral terminals and the outgoing terminals of the master control switch. If continuity tests had been carried out they would have shown the switch to be faulty.

51 Two men were killed when a 24.4m (80ft) high steel cylindrical vessel ruptured. It was being purged with nitrogen at a pressure of 6.9 bars (100 psi). The vessel was not designed to withstand such pressure. The top blew off while the two men were investigating a leaking valve. The purge nitrogen should have been vented and pressures monitored.

52 A chargehand fitter was crushed against the auxiliary hoist machinery by the main hoist crab travelling overhead on a charger crane in a steelworks. A permission to board system had been instituted six years before. The system had fallen into abuse and the deceased failed to follow the procedure.

53 A fitter became entangled with a tail drum and projecting shaft on a troughed conveyor. He was attempting to 'track' the belt at the tail drum. The side guard had been removed to allow access to the adjusting mechanism.

54 A fitter was buried by sand and asphyxiated, while repairing a hopper at a concrete batching plant. The plant was in continual use and sand was discharged from the hopper into a mixing vehicle. The deceased was sucked down. There was no permit to work system and the plant had not been isolated.

55 A mechanical craftsman in a power station was crushed under the top half of a turbine casing which had been removed to allow access to the inside. He took off one of the two nuts supporting one end of a 2 tonne (1.97 tons) diaphragm and the other stud failed. Later it was found that the second stud was already cracked.

56 A works manager was crushed between the rear of a fork lift truck and a furnace on which he was working. The fork lift truck shot backwards across the workshop floor. The driver had no previous training, supervision or experience of driving. He could not drive a car.

57 A man fell 3m (10ft) from a plywood board, which slipped, onto a concrete floor. He had climbed a step ladder onto the roof of a spray booth which was being refurbished. From there he stepped onto the board, one end of which was resting on angle iron reinforcement and the other on a fire sprinkler water supply pipe.

58 An oil refinery operator was burnt to death while trying to close a drain valve. A reformer unit had been shut down for maintenance. A column contained several tons of petrol and LPG at 49°C (300°F) and 13.1 bars (190 psi). This material should have been pressurised to storage by a closed system. A drain line on the column designed to drain off condensate was opened in error. The escaping hydrocarbons vapourised rapidly and ignited.

59 A director of a newly established company was asphyxiated by trichloethylene fumes. He was working on his own and went into a standard degreasing tank to check the bottom. There were a few gallons of trichloroethylene in the tank and he collapsed and died before he was found.

60 A rigger fell 36.6m (120ft) from a platform while working in a gang replacing the crane ropes on the cross travel carriage of an ore unloader. The work was nearly finished when one of the ropes suddenly tightened. The rigger was struck in the chest by a shackle and pitched over the guard rail. He should have been in the machinery house when the reeve winch was operated.

61 Two men, one of whom died, were standing on a 3mm (one-eighth inches) steel plate underneath the tail unit of a conveyor when it gave way. They fell 12.2m (40ft) to the ground. The plate was badly corroded.

62 A labourer was asphyxiated while using methylene chloride as a solvent cleaner in a confined space. He had been instructed to clean the internal surface of a small compartment within a submarine oil tank. His foreman had forbidden him to use cleaning fluids.

63 A service engineer was electrocuted while repairing an ozone generator installed in the plant room of a swimming pool. He restored power to the generator which resulted in a fuse blowing. Knowing that the HT side of the generator was dead it appeared that he reached into the cabinet to remove the HT lead. His left hand touched the bare terminals of the heater bands energised at mains potential.

64 A contract electrician fell 9.1m (30ft) from the walkway of an overhead travelling crane. He was working on the auxiliary lighting system to the crane. Tests indicated that a length of metal conduit from which a lamp was hanging was live at 410 volts DC.

65 A production operative fell 3.7m (12ft) from the frame of a paper making machine. He was helping to remove broken paper from around the drying cylinder. The deceased, contrary to instructions, used the felt conditioner as access and stood on the rear frame while attempting to restrain the paper making felt. A ladder was available to reach the broken paper.

66 A chargehand pipe fitter was scalded and burnt by an escape of steam while working inside a large tank in a steelworks. A steam coil system was common to two sections of the tank. The man isolated only one valve to one part of the coil system. There was another valve 4.6m (15ft) away which should have been closed so as to complete the isolation of the system. The pipe fitter 'broke' the flange on the pipe containing 'live' steam and he was killed by the resultant escape.

67 An insurance company lift inspector was crushed by the car of a passenger lift while carrying out a statutory examination. It appears that he was on top of the lift car but failed to put the controls onto 'test'. He neglected to place warning notices at the landings. Someone called the car, the lift moved and crushed him.

68 An 18 year old farm worker was killed while cleaning the barrel of a cement mixer driven by a tractor mounted power take off. He operated the hydraulics from the rear of the tractor and was trapped between the mixer and the tractor wing.

69 A farm worker was found entangled in the rotating discharge shredders of a forage trailer. He was attempting to rake silage from the front of a forage trailer to expose a broken link in the moving floor chain. He had left the beaters and cross conveyor running. This system of work had been used previously when the farmer had been present.

70 A farmer's daughter was electrocuted whilst using an electrically driven high pressure washer to clean a turnip harvester. It is thought that the earth and neutral cables in a 15 amp plug became detached when she tripped over the cable.

71 A farmer, working under a plough supported on the hydraulic linkage of a tractor was crushed when the plough suddenly descended. The tractor engine was left running so that vibration caused the control lever to move causing the plough to drop.

72 A farm worker cleaning a forage box was trapped in its power driven beater machanism. He was told only to clean out the shed in which the forage box was housed and was found by the farm manager later in the day. It was assumed that he had taken upon himself to clean out the forage box and entered it while the rear beaters were in motion.

73 Whilst trying to close the stone trap door under a stationary combine harvester the header unit fell onto a farm labourer as he lay under it. He had raised the header unit using the hydraulics and with the engine running went underneath. He was closing the door with the special tool using his foot to gain extra leverage. Either the tool or his foot slipped fracturing metal pipe which fed oil to the header lift rams.

74 A farmer became entangled on the unguarded revolving shaft of a power take off driving a hay tedder. He was attempting to make a groove in the shaft using a file in order to fit a guard. He was not found for some hours and had died from shock and loss of blood.

75 A farmer accidentally pushed the engine starter mechanism of a combine harvester. The machine moved off trapping him under the drive wheels. He was working under the pick up bed carrying out adjustments to the fuel lines or battery terminals.

76 A fitter was crushed between a mine car and fixed parts of a semi-automatic underground mine car tippler installation. He was trying to repair an intermittent fault. The machine suddenly started. Isolation procedures were not used.

77 An attendant was found with his arm trapped between the belt and deflection roller of an underground coal transfer conveyor. A ladder had been used to reach the drive unit, 2.6m (8ft 6in) above floor level, and a shovel to clear away debris.

78 During repairs to a coal face shearing machine a fitter became entangled in the shearer drum which was started in order to lower an adjacent jack. The original design did not allow independent operation of these two parts.

79 A face worker cleaning the end roller of an underground conveyor with a shovel was drawn into the inrunning nip between the belt and drum. The side plates of the guard extended only 0.45m (1ft 6in) from the nip point.

80 A greaser fell from the structure of a coal drilling rig when checking oil and water levels. The decking did not extend to this part of the machine.

81 A pinch bar pivoted violently striking a fitter on the head during weekend maintenance of rock crushing machine.

82 The driver of a peat milling machine was found with his clothing wrapped around the coupling of the unguarded power take off shaft of a tractor. Repairs were being carried out to a nearby linkage of a hydraulic ram.

83 An underground conveyor was stopped and isolated in order to clear away a build up of coal debris in the tail end roller. A worker lay between the top and bottom belts to reach and clean out the unguarded end drum. Sudden forward motion of the belt as he released the blockage caused his arm to be drawn into the inrunning nip between the belt and drum. The belt had remained under-tension until released by this clearance work because a sprag clutch prevented its reversal.

84 A coal face conveyor stalled due to spillage. It was locked out while a face worker attempted to clear compacted debris from the end drum. The belt was held under tension by sprag clutches. It was suddenly released and he was drawn into the poorly guarded inrunning nip between the belt and drum.

85 An attendant entrered a transfer point enclosure to clear a blockage from a staionary conveyor. Coal discharged from the bunker, smothering him. Stopping the conveyor did not also isolate the bunker discharge mechanism. Access gates were not interlocked.

86 A surface mechanic was drawn into the nip point between the belt and roller of a coal preparation plant conveyor. He was scraping fines from the roller using a rake. An insecure guard was pushed aside.

87 A fitter was adjusting the tracking of a conveyor belt on the surface at a metal ore mine. The guards had been removed. His arm was drawn into the nip between the belt and pulley.

88 A greaser was crushed between two box scrapers at an opencast coal quarry, when he was checking coolant levels. The gear selector interlock and brakes were found to be faulty.

89 The operator of a coal cutting machine became entangled in the picks when clearing a blockage of stone from the delivery hopper. The machine was not isolated before starting this task.

90 A maintenance worker was transporting a replacement belt to a conveyor system along a coal mine sloping underground roadway. The trolley rolled down the slope trapping him against an arch girder. Adequate clearance was not maintained in the roadway.

91 A fitter was crushed between the fixed and moving parts of a coal mine tunnelling machine during routine servicing. Isolation procedures were not used, and the pre-start warning device could not be heard.

92 A chargehand fell onto a moving coal conveyor in a surface stockyard, as he was trying to clear a blockage. He was buried under the accumulated coal. A newly erected loading hopper in the conveyor system was not working properly, causing operating problems. Safe working systems had not been established.

93 A mechanic was repairing a coal face drill rig, when it started up. He was trapped between the moving conveyor and fixed parts of the machine. The plant was not isolated, and the pre-start warning device was barely audible.

94 Following the replacement of a mine shaft coal skip, a shaftsman was preparing to remove the temporary work platform across the shaft. The skip arrived at some speed at the top of the shaft, scattering the wooden battens and trapping the workman. Unknown to the engineman the winding rope had been shortened for a previous operation. The skip was within 170m (558ft) of the surface. In these circumstances the speed sensing device on the engine did not give the normal protection.

95 A conveyor attendant was cleaning coal fines from the drum of an underground conveyor, when the belt slipped through a temporary belt clamp crushing him against the drum. There was sufficient residual energy to cause rapid motion. The clamp was found to be bowed.

96 A tapered wooden pole was used to remove wet coal from a weld mesh box around a conveyor deflection roller. The attendant was found with his arm trapped between the belt and roller. Part of the guard was missing.

97 An attendant was entangled in the unguarded gear train of a rotary barrel washing machine in a quarry. A tin of lubricant was found nearby.

98 The guards of an inclined belt conveyor in a stone quarry were removed to clear a spillage. An operator was poking a stick into the gravity take up unit, when he was drawn into the inrunning nip between the belt and pulley.

99 An operator became trapped in the unguarded rope drum of a dragline in a quarry. He was preparing to change the frayed rope. The throttle cable did not work correctly, so the engine was run at a fixed high speed.

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Hand-held electric motor-operated tools
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BS 2769 : Section 2.2
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BS 2769 : Section 2.3 : 1984
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BS 2769 : Section 2.8 : 1984
Specification for sheet metal shears and nibblers
BS 2769 : Section 2.9 : 1984
Specification for tappers
BS 2769 : Section 2.10 : 1984
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BS 2769 : Section 2.12 : 1984
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BS 5304 : 1975
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BS 5744 : 1979
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FILMS

Motor vehicle repair
Talking cars
1982 (UK 3521)
15 mins, 16mm colour CFL
(Hazards and unsafe working practices in garage workshops)

Cause Unknown 1976
11 mins, 16mm Post Office
(The working day of two mechanics culminating in a serious accident)

Under the Car 1969
4 mins, 16mm RTITB
(Safe working practices under vehicles)

Confined spaces
Watch that space - confined space hazards in shipbuilding 1978 (UK 3381)
15 mins, 16mm colour CFL
(The dangers from toxic or flammable gases in confined spaces

Watch that space - confined space hazards in factories 1978 (UK 3380)
19 mins. 16mm colour CFL
(The hazardous nature of work in confined spaces)

Watch that space - confined space hazards in the construction industry 1978 (UK 3379)
16 mins, 16mm CFL
(Re-construction of a typical accident involving entry through a manhole)

Overhead or buried electric cables
Alive ... or dead?
1982 (UK 3645)
21 mins, 16mm colour CFL
(Shows the dangers associated with overhead or buried electric cables, emphasising safe procedures)

Roofwork
One step away
1978 (UK 3396)
15 mins, 16mm colour CFL
(Accidents during the building and maintenance of roofs, highlights the golden rules for safe working)

Building Maintenance
Too much Trouble
1983 (UK 3712) 20 mins, 16mm or video cassette CFL
(Illustrates how tragedy can strike during basic building maintenance work)

Electrical Equipment
Electrical Safety on the Farm
1983 (UK 3701)
13 mins, 16mm or video cassette CFL
(Looks at common problems with electrical equipment and systems ie poor installation, maintenance or repair)

Machinery
Principles of Machinery Guarding
1977 (UK 3355)
10 mins, 16mm or video cassette CFL
(An outline guide to the provision, maintenance and correct use of machinery guarding)

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Central Film Library
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